PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

1838–9. No. 14.

Monday, 3*d December* 1838.

Lord GREENOCK in the Chair.

The following Donations were presented:

The Journal of the Royal Geographical Society of London. Vols. i. to vii., and Vol. viii. Part 1.—*By the Society.*

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences 1838. 1er Semestre, Nos. 17 to 26. 2^{me} Semestre, Nos. 1. to 20.—*By the Academy.*

Annalen der Physik und Chemie. Herausgegeben zu Berlin, von, J. C. Poggendorff. 1837, Nos. 10, 11, 12.—*By the Editor.*

Researches on Heat. 3d Series. By James D. Forbes, F.R.SS.L. & E.—*By the Author.*

Nova Acta Physico-Medica Academiæ Cæsareæ Leopoldino-Carolinæ Naturæ Curiosorum. Vol. xviii. Part 1.—*By the Academy.*

Statistique de la Grande-Bretagne et de l'Ireland, par Alex. Moreau de Jonnés. 2 tomes.—*By the Author.*

The American Journal of Science and Arts. Conducted by Benjamin Silliman, M.D., LL.D. For January and April 1838. —*By the Editor.*

Bulletin de la Société Géologique de France. Tome ix. Feuilles 6–19.—*By the Society.*

Journal of the Statistical Society of London, for June, July, August, September, October, and November.—*By the Society.*

Mémoires de la Société de Physique et d'Histoire Naturelle de Geneve. Tome viii. Part 1.—*By the Society.*

The Fifth Report of the Royal Cornwall Polytechnic Society, 1837.—*By the Society.*

A Dissertation on the Nature and Character of the Chinese System of Writing, in a Letter to John Vaughan, Esq. By Peter S. Du Ponceau, LL.D., President of the American Philosophical Society, &c.—*By the American Philosophical Society.*

Journal of the Asiatic Society of Bengal for December 1837 and February 1838.—*By the Society.*

Proceedings of the Geological Society of London. No. 56.—*By the Society.*

Revue Zoologique par la Société Cuverienne, No. 1.—*By the Society.*

Astronomische Nachrichten, Nos. 337 to 348.—*By Professor Schumacher.*

Astronomical Observations made at the Royal Observatory, Edinburgh. By Thomas Henderson, F.R.S.E. and R.A.S., &c.—*By the Royal Soc. of London.*

Maps of the Ordnance Survey of Great Britain, Nos. 49, 50, 66, 67, and 68.—*By the Board of Ordnance.*

The Malacological and Conchological Magazine. Conducted by G. B. Sowerby, F. L. S., &c. &c. &c. Part 1.——*By the Editor.*

Nieuwe Verhandelingen der Eerste Klasse van het Konninklijk-Nederlandsche Instituut van Wetenschappen, Letterkunde en Schoone Kunsten te Amsterdam. Deel 7. Stucks 1, 2, 3.—*By the Institute.*

Elements of Chemistry, including the Applications of the Science to the Arts. By Thomas Graham, F. R. SS. L. & E., &c. Part 2.—*By the Author.*

Fifteenth Report of the Whitby Literary and Philosophical Society, presented at the Annual Meeting, October 31. 1837.—*By the Society.*

Statistical Report on the Sickness, Mortality, and Invaliding among the Troops in the West Indies. By Captain Alex. Tulloch and Henry Marshall, Esq.—*By the Authors.*

Description Nautique des Côtes de l'Algerie, par M. A. Berard, Capitaine de Corvette ; suivies de Notes par M. de Tessau

Ingenieur-Hydrographe, 1837. 8vo, avec Carte.—*Par le Directeur General du Dépot des Cartes de la Marine.*

Bulletin de la Société de Géographie. Deuxieme serie. Tome ix. —*By the Society.*

Transactions of the Society for the Encouragement of Arts, &c. Vol. li. Part 2.—*By the Society.*

Mémoire sur la Chaleur Solaire, sur les pouvoirs rayonnants et absorbants de l'air Atmospherique, et sur la Temperature de l'espace. Par M. Pouillet.—*By the Author.*

Flora Batava, Nos. 114, and 115.—*By the King of Holland.*

Tijdschrift voor Natuurlijke Geschiedenis en Physiologie. Uitgegeven door J. Van Der Hoeven, M.D., en W. H. De Vriese, M.D. Deel iv. Stucks 3, 4.—*By the Editors.*

Minutes of Proceedings of the Institution of Civil Engineers.—*By the Institution.*

An Experimental Essay on the Physiology of the Blood. By Charles Maitland, M.D.—*By the Author.*

Christiani Hugenii aliorumque seculi xvii. Virorum celebrium Exercitationes Mathematicæ et Philosophicæ ex Manuscriptis in Bibliotheca Academiæ Lugduno-Batavæ servatis. Edidit Petrus Joannes Uylenbroeck in eadem Academia Physices et Astronomiæ Prof. Extraord. Fascic. 1, 2.—*By the Academy.*

Transactions of the American Philosophical Society held at Philadelphia for promoting Useful Knowledge. New Series. Vol. vi. Part 1.—*By the Society.*

Transactions of the Royal Irish Academy. Vol. xviii. Part 1.—*By the Academy.*

Proceedings of the Royal Irish Academy for the Year 1837–38. Part 2.—*By the Academy.*

Second Report of the Commissioners appointed to consider and recommend a General System of Railways for Ireland, with Atlas, Plans, and Sections of the several lines.—*By the Irish Railway Commissioners.*

On the present state of our Knowledge in regard to Dimorphous Bodies. By J. F. W. Johnston, M. A.

The Economy of a Coal-Field. By J. F. W. Johnston, M. A.
By the Author.

Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Konigl. Preuss. Akademie der Wissenschaften zu Berlin vom Juli 1837 bis Juni 1838.

Abhandlungen der Koniglichen Akademie der Wissenschaften zu Berlin, 1836. *By the Academy.*

The Seventh Report of the British Association for the Advancement of Science, held at Liverpool in 1837.—*By the Association.*

Eloge Historique d'Antoine Laurent de Jussieu, par M. Flourens. —*By the Author.*

Catalogue of the Chinese Library of the Royal Asiatic Society.

Journal of the Royal Asiatic Society of Great Britain and Ireland. No. ix. for August 1838. *By the Society.*

Mémoires de la Société Geologique de France. Tome iii. Part 1.—*By the Society.*

Eighteenth Report of the Council of the Leeds Philosophical and Literary Society, at the close of the Session 1837-38.—*By the Society.*

The American Almanac and Repository of Useful Knowledge for the Year 1839.

Proceedings of the American Philosophical Society, January to August 1838. *By the Society.*

Recueil d'Observations Magnétiques faites à St Petersbourg et sur d'autres points de l'Empire de Russie. Par A. T. Kupffer.—*By the Author.*

Bulletin de la Société Impériale des Naturalistes de Moscow. 1837, Nos. 5, 6, 7, 8; and 1838, Nos. 1, 2, 3.—*By the Society.*

Recherches sur le Mouvement et l'Anatomie du Stylidium Graminifolium. Par Ch. Morren, Professeur de Botanique à l'Universitie de Liege.—*By the Author.*

Ten other Botanical Tracts.—*By the same Author.*

On a New Correction in the Construction of the Double Achromatic Object Glass. By Richard Potter, Esq.—*By the Author.*

Sketch of the Geology of Exeter and the Neighbourhood. By T. Shapter, M. D.—*By the Author.*

Documents and Records illustrating the History of Scotland, and the Transactions between the Crowns of Scotland and England, preserved in the Treasury of Her Majesty's Exchequer. Collected and Edited by Sir Francis Palgrave, K. H. Vol. i. —*By the Commissioners on the Public Records.*

Annalium Societatis Eruditæ Hungaricæ Volumen Tertium.—*By the Society.*

Memoirs of the Royal Academy of Stockholm for 1836.

Annual Reports on the Progress of the Sciences, presented to the Royal Academy of Stockholm in 1836.—*By the Academy.*

Maps of the Ordnance Survey of Ireland.—*By the Lord Lieutenant.*

The Quarterly Journal of Agriculture; and the Prize-Essays and Transactions of the Highland and Agricultural Society of Scotland. For June, September, and December 1838.—*By the Society.*

The following Communication was read:

Discussion of one Year's Observations of Thermometers sunk to different Depths in different localities in the neighbourhood of Edinburgh. By Professor Forbes.

These observations were made, at Professor Forbes's suggestion, at the expense of the British Association. They are still continued, and the present notice contains only a first approximation to the solution of the problems which they are intended to give.

The chief aim of the experiments is to ascertain the progress of Solar Heat in the Crust of the Globe, and has no *immediate* reference to the question of central heat; the depth to which the experiments extend being inadequate to afford decisive results on that head.

The experiments differ in their object from any hitherto made, from having an especial regard to the structure of the soil and the conducting power for heat of different geological formations. With this view three series of thermometers were constructed by Mr Adie, under Mr Forbes's directions, each nearly of the same length and range, and these were sunk in holes prepared for them to precisely similar depths, (1.) in the Trap Tufa of the Calton Hill, within the Observatory grounds; (2.) in the homogeneous bed of Sand at the Experimental Garden; and (3.) in the compact Coal Formation Sandstone of Craigleith Quarry, all in the immediate neighbourhood of Edinburgh, and within a radius of about a mile. With a view to render these observations more immediately comparable with those made at Paris and Brussels, the extreme depth was the same, or the lowest thermometer had its bulb at the distance of 24 French feet (= 25.6 English) below the surface, and the others were placed at each station at depths of 12, 6, and 3 French feet.*

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* At the Observatory a thermo-electric pair of iron and copper wires

The tube which connected the bulb with the reading part above ground was made capillary, so as to contain as little liquid (alcohol) as possible. Notwithstanding, all the observations have been rigorously corrected for the inequality of temperature of their stems, and likewise for the expansion of the liquid above ground. The observations were commenced in February 1837, and have been made once every week since. After being corrected they were projected in the form of Curves: and the general consistency of these with one another, and the peculiarities proper to each station, are such as to give considerable confidence even in the first approximation, which extends from February 1837 to February 1838.

I. The general form of the curves at all the stations corresponding to different depths agrees perfectly with what has hitherto been observed under similar circumstances. As we descend, the curve becomes more even, and flatter, the range rapidly diminishing, and the epochs of minimum, mean, and maximum temperature occur later.

II. The mean temperature of the soil appears to increase as we descend (this has been observed at Brussels and elsewhere). At the Experimental Garden the mean annual temperature is, at 3 feet (French), 45°.54 Fahr.; at 6 feet, 46°.70; at 12 feet, 46°.90; at 24 feet, 47°.28. The Craigleith observations are ambiguous in this respect.

III. The annual ranges at the three stations and at the different depths, are the following:

	3 Feet.			6 Feet.		
	Observatory.	Garden.	Craigleith.	Observatory.	Garden.	Craigleith.
Fahrenheit,	18°.95	19°.65	17°.25	11°.9	14°.95	13°.9
Centigrade,	10 .53	11 .23	9 .58	6 .61	8 .30	7 .72

	12 Feet.			24 Feet.		
	Observatory.	Garden.	Craigleith.	Observatory.	Garden.	Craigleith.
Fahrenheit,	5°.5	7°.55	9°.4	1°.45	2°.1	4°.1
Centigrade,	3 .05	4 .19	5 .22	0 .80	1 .16	2 .28

Now it is known by theory that the range ought to diminish in geometrical progression as the depths increase arithmetically; and accordingly these results may be very closely represented by logarithmic curves, having different Moduli at each station, depending

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was sunk along with the deepest thermometer, with a view to test the applicability of M. Peltier's apparatus to this object. Several observations closely agreeing with the thermometer have thus been made.

on the nature of the soil. If Δ_p denote the range in Centigrade degrees at a depth p, and A and B two constants, we have

$$\text{Log.}\ \Delta_p = A + Bp$$

And B depends upon $\sqrt{\frac{\text{specific heat}}{\text{conductivity}}}$ of the soil. Now this constant B is found to have the following negative values: [*]

Observatory —0.0547; Garden — 0.0440; Craigleith — 0.0317.

Consequently the conducting power of the strata is in the order just written, the first being the lowest, the last the greatest (supposing the difference of specific heat immaterial). By extending the Logarithmic curve, the depth at which the range has any amount may be found.[†] Thus the range will be reduced to $\frac{1}{100}$ of a Centigrade degree, or may be reckoned insensible, at the following depths:—

Observatory, 58 feet; Experimental Garden, 72 feet; Craigleith, 97 feet.

Now it is remarkable that the above variations in the value of B exceed those contained in M. Quetelet's table, which includes all the observations made in different parts of Europe; shewing that the increase of the value of B with the Latitude, which was thought to have been observed (Quetelet, *Mémoire sur les Variations Diurne et Annuelle de la Temperature Terrestre*, p. 61), was quite accidental; and that the value of B must depend solely on the constitution of the soil in which the experiments are conducted.

IV. The epochs of the winter minimum of 1837 are ill determined for the upper thermometers, owing to the great irregularity of the winter curve, and also because the observations were commenced too late to obtain them correctly. The epochs of maximum temperature give, however, a complete confirmation of theory, and of the preceding deductions. We find that, with a single exception (the shortest thermometer at Craigleith), and that exception is doubtful, all the thermometers at Craigleith attained their maximum first, then those at the Experimental Garden, and lastly, at the Observatory, as the following table shews:—

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[*] In order to render the results directly comparable with those in M. Quetelet's excellent paper in the Brussel's Transactions, the French foot and Centigrade degree are employed as unities.

[†] The values of A are 1.164, 1.176, 1.076 in the same order as before.

	Maximum at			
	3 *Feet.*	6 *Feet.*	12 *Feet.*	24 *Feet.*
Observatory,	August 6.	September 2.	October 17.	January 8.
Exper. Gar.	July 31.	August 24.	October 7.	December 30.
Craigleith,	August 5.	August 19.	September 11.	November 11.

We also find, as theory assigns, the retardation of the maximum increases arithmetically with the depth. So that, if we project these observations and cause an interpolating straight line to pass through the points for each station, we find that the progress of heat downwards is,

At the Observatory,	1 foot in	7.5 days.
.... Experimental Garden,	......	7.1 ...
.... Craigleith Quarry,	......	4.9 ...

giving the same order of conducting power as before.

The bearing of these experiments on geological theories, and especially on the movement of the Isothermal lines in the interior of the globe, is evident.

Monday, 17th December 1838.

Dr ABERCROMBIE in the Chair.

The following Donations were presented:

Mémoires Couronnés par l'Académie Royale des Sciences et Belles Lettres de Bruxelles. Tomes xii. and xiii.

Bulletin des Séances de l'Académie Royale des Sciences et Belles Lettres de Bruxelles. 1837, Nos. 10, 11, 12. 1838, Nos. 1, 2, 3, 4, 5, 6, 7, 8.

Annuaire de l'Académie Royale des Sciences et Belles Lettres de Bruxelles pour l'an 1838. *By the Academy.*

Annuaire de l'Observatoire de Bruxelles pour l'an 1838, par le Directeur A. Quetelet.—*By the Author.*

De l'Influence des Saisons sur la Mortalité aux differens Ages dans la Belgique, par A. Quetelet.—*By the Author.*

Résumé des Observations Météorologiques faites en 1837 à l'Observatoire de Bruxelles, et communiquées par A. Quetelet.—*By the Author.*

Recherches sur les Propriétés des Courants Magnéto-Electriques, par M. le Prof. Aug. de la Rive.—*By the Author.*

Examen Critique d'un Mémoire de M. P. Leroux, intitulé du Bonheur, par L. A. Gruyer.—*By the Author.*

Discurso lido em 15 de Maio de 1838 na Sessas publica da Academia Real das Sciencias de Lisboa, par Joaquim José Da Costa de Macedo.—*By the Academy.*

Astronomische Nachrichten, Nos. 349 to 354.—*By Professor Schumacher.*

Mémoires de l'Académie Impériale des Sciences de St Petersbourg. (Sciences Mathématiques, &c.) Tome i. livrs. 5, 6; et tome ii. livrs. 1, 2.

Do. do. (Sciences Naturelles). Tome ii. livrs. 4, 5, 6.

Do. do. (Mémoires présentés par divers Savans). Tome iii. livrs. 3, 4, 5, 6; et tome iv. livrs. 1, 2.

Recueil des Actes de la Séance Publique de l'Académie Impériale des Sciences de St Petersbourg tenue le 29 Décembre 1837. —*By the Academy.*

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, 1838. (2^{me} Semestre). Nos. 21, 22.—*By the Academy.*

Natuur-en-Scheikundig Archief, uitgegeven door G. J. Mulder en W. Wenckebach. Jaargang 1837. 3d Stuk.—*By the Editors.*

The following Communications were read:

1. On the Law which connects the Elastic Force of Vapour with its Temperature. By John Scott Russell, Esq.

The object of the paper was to examine into the present state of our knowledge of this subject, for the purpose of ascertaining its defects, and indicating the manner in which they were to be remedied.

Although it appears to any one who examines only a single authority on the constitution of vapour, that its laws are sufficiently definite, yet on comparing together all the authorities we possess on this subject, or even the best of them, we find such discrepancies both in the general expressions of the law, and in the experiments themselves upon which they rest, as are highly discreditable to mechanical science, and far exceed the limits of error usually admitted in similar departments of experimental science. Between 32° and 212°, the difference between Dr Dalton's experiments and Dr Ure's amounts to more than three-tenths of an inch of mercury. Between the experiments of the Institute of France and of the Franklin Institute,—the latest and most extensive series of experiments,—there is a difference at the eleventh atmosphere

of more than 6° in temperature, and about 20 inches of mercury in the pressure of the vapour.

The author entered into a comparison of the empirical formulæ which have been successively employed to express in mathematical terms the simultaneous progressions of temperature and elastic force. These are of two classes: the first comprehends the formulæ of Prony, Laplace, Biot, and Ivory, in which the elasticity is the sum of the terms of an infinite series, of which five terms at least now require to be taken; and it was shewn that, even with an operation so tedious and laborious, the results of calculation differ from those of experiment still more widely even than those from each other. The formulæ are as follows:—

(1.) $F_t = \mu \varrho^t + \mu_{,} \varrho_{,}^t + \mu_{,,} \varrho_{,,}^t$ &c. . . . . Prony.

(2.) $F_t = \text{Log } 760 + \alpha t + \beta t^2 + \gamma t^3 +$ &c. . . Laplace.

(3.) $F_t = 0^2.76 . 10^{A t + B t^2 + C t^3 + \&c.}$ . . Biot.

(4.) $F_{\frac{t}{30}} = 0.0087466 t - 0.000015178 t^2 + 00000002483 t^3 +$ Ivory.

The other class of formulæ are those of Dr Young and his followers. He was the first to give a manageable expression of a simple form, in which the expression for the elastic force of the vapour is merely a multiple of the temperature, increased by a constant quantity, and placed under the index 7. This simpler expression, although absolutely empirical, having been selected by Dr Young, as he candidly avows, from above a dozen others, merely because it happened to approximate to the best experiments he at that time possessed, yet has been almost invariably followed ever since. But while the form of the expression has been preserved, it has been found necessary to alter the value of its terms at each step of experimental research, in such a manner that this branch of knowledge now appears to have become degraded to the very lowest degree of empiricism. Dr Young's expression having been found too high for the subsequent experiments of Southern, the index was reduced from 7. to 5.13. Dr Ure's experiments next made their appearance, and forthwith the index 7 being found too great, and 5.13 too small, the number 6. was adopted as best representing *them*. The subject being next examined by M. Coriolis, who, reviewing the works of all his predecessors, found none of them sufficiently consistent, he satisfied himself with taking an average of the whole, and obtaining as an index the mean number

5.355. But Mr Tredgold, arguing that a fractional number was not likely to represent a law of nature ! restored the index 6. His decision has been overturned by the Commission of the Academy of Sciences, who have adopted the number 6, as best representing their higher experiments; and last of all, this decision is reversed by the Committee of the Franklin Institute of Philadelphia, who alter other terms of the formula, but reinstate the index 6.

These formulæ are :—

(5.) $F_t = (0.0029\,t + 1)^7$ . . Dr Thomas Young.

(6.) $F_t = \frac{(t + 51.3)^{5.13}}{37344{,}000{,}000} + 0.1$. Mr Southern.

(7.) $F_t = \left(\frac{t}{168.57}\right)^6$ . . . . Mr Crighton.

(8.) $F_t = \left(\frac{0.01878\,t + 1}{2.878}\right)^{5.355}$. Mr Coriolis.

(9.) $F_t = \left(\frac{t + 100}{177}\right)^6$ . . Mr Tredgold.

(10.) $F_t = (0.7153\,t + 1)^5$ . . French Academy.

(11.) $F_t = (0.00333\,t + 1)^6$ . . Franklin Institute.

The author next proceeded to examine the theoretical views of Dr Dalton. From long calculations, and laborious discussions of the experiments and formulæ, he has been led to the conclusion that, with certain modifications, these views represent the actual state of our knowledge of this subject better than any of these empirical formulæ. Dr Dalton finds, that, if the scale of temperature which he considers as the true scale be reckoned from a zero at 175° lower than the present scale of Fahrenheit, the progressions of the temperatures being as the square root of the expansions of the mercury, then the progression of the elasticities will be in geometrical ratio to those equal or true intervals of temperature. By modifying this hypothesis, so as to reduce it to the following, that the intervals of the common scale are in a geometrical ratio to the intervals of true temperature, reckoned from a point 175° below the present zero, Mr Russell finds that he obtains formulæ that perfectly represent the best series of experiments,—so closely indeed, that the greatest difference between theory and experiment does not exceed $\frac{8}{100}$ of an inch of mercury from 0° to 212°, and as far as 25 atmospheres does not average half a degree. He also adduces ground for supposing that the theory of temperature on which this rests is the only tenable one. The first equation is of this form:

$$\frac{t+i}{c} = r^{\frac{\text{Log. F}}{\text{Log. } m}}$$

whence the experiments of Dr Dalton are accurately represented by the expression

$$(12.) \ldots\ldots\ldots\ldots \frac{t+175}{387} = 1.1320^{\frac{\text{Log. F.}}{\text{Log. } 2.602}}$$

But it is remarkable that, if one series of experiments below 212° be taken, and any other above 212°, the expression which accurately represents the one will widely deviate from the other. So that, though a formula of the same nature represent the experiments of the French Academy and of the Franklin Institute very accurately, it requires different constats. If we average Dr Dalton's and Dr Ure's below 212°, and those of the Academy and Institute above that point, we find they coincide more nearly with the following formula than with each other:

$$\frac{t+121^\circ}{333^\circ} = 1.11401^{\frac{\text{Log. F}}{\text{Log. } 2}}$$

From the whole investigation, the author arrives at the following conclusions:—(1.) That the discrepancies between the most recent and extensive experiments we possess are so great, as to leave this branch of experimental science in a disgraceful state of uncertainty, and that it is desirable that those who are engaged in experiments on heat, would revise this useful and interesting branch of inquiry; and it is suggested that, for this purpose, *the same apparatus and methods* of experiment which are employed in the experiments *below* atmospheric pressure, should also be those which are employed at high temperatures *above* atmospheric pressure. (2.) That the most accurate experiments we are in possession of at pressures below 212° are Dr Dalton's recent ones, which accurately coincide with the hypothesis that the intervals of the common scale are to those of true temperature, in a geometrical register, reckoned from the zero point of the mercurial thermometer 175° below the zero of Fahrenheit, and of which the common ratio is 1.1320, the corresponding elastic forces forming the logarithmic progression to the true temperatures, whose index is 2.602. That the mean of the experiments of Dr Dalton, Dr Ure, the French Academy, and the Franklin Institute, give 1.11401 as the ratio of progression of the temperatures, 2. being the index of the progression of elastic force, and —121° the zero of same temperature. (3.) That Dr Dalton's theory of temperature does, with very slight modifications, represent accurately our knowledge of the law which connects the temperature with the elastic force of vapour. (4.) Expressions may be derived from this theory of the same form as the empirical formulæ at present in use; and these are:

For Dr Dalton's experiments below 212°, the temperature being reckoned from —175°, or $t =$ temp. F. $+ 175°$.

(14.) .... $\text{Log } t = 0.12965 \log F + 2.587711$

(15.) .... $\text{Log } F_t = 7.71307 (\log t - 2.587711)$

For the mean of the experiments of the French Academy and the Franklin Institute above 212°, the temperature being reckoned from —121° or $t =$ temp. F. $+ 121°$.

(16.) .... $\text{Log } t = 0.1557634 \log F + 2.5224442$

(17.) .... $\text{Log } F_t = 6.42 (\log t - 2.5224442)$

For the following substances, we obtain, by means of a single modulus or constant number, derived from Dr Dalton's experiments for each substance, which is substituted for 2.602, the modulus for vapour of water in equation (12). This modulus is 2.57 for acetic acid, 2.700 for alcohol, 1.978 for sulphuret of carbon, and 2.00 for ether; and the formulæ are as follows:—

Alcohol .... $\left\{\begin{array}{l} \text{Log } t = 0.12483 \log F + 2.5428254 \\ \text{Log } F_t = 8.01090 (\log t - 2.5428254) \end{array}\right.$

Ether .... $\left\{\begin{array}{l} \text{Log } t = 0.178873 \log F + 2.4345689 \\ \text{Log } F = 5.59063 (\log t - 2.4345689) \end{array}\right.$

Acetic Acid............ $\left\{\begin{array}{l} \text{Log } t = 0.13116 \log F + 2.5965971 \\ \text{Log } F = 7.52427 (\log t - 2.5965971) \end{array}\right.$

Sulphuret of Carbon $\left\{\begin{array}{l} \text{Log } t = 0.18277 \log F + 2.4548449 \\ \text{Log } F = 5.4714 (\log t - 2.4548449) \end{array}\right.$

2. Abstract of a Paper on Results of Observations made with Whewell's New Anemometer. By Mr John Ranken. Communicated by Professor Forbes.

In laying the results of these observations before the Society, it was thought necessary to make a few remarks in explanation of the manner in which they were made.

The instrument consists of a fixed japanned cylinder, on which the points of the compass are marked, and a moveable portion, which revolves freely round the cylinder as the wind changes; the circular disk of a fly kept opposite to the wind by a weathercock vane, is made to revolve with a velocity proportional to that of the wind. The motion thus produced is diminished by means of endless screws, working in a pair of toothed-wheels, and carried down to a pencil, which, in its descent, rubs on the surface of the cylinder, and traces a broad line, whose length is proportional to the velocity of the wind, and the time during which it blows from any one direction taken jointly. The compartment of the cylinder on which the marks are made indicates the direction of the wind.

It was stated that the indications of this anemometer differed from those of former ones, in so far as the *integral effect* of the wind for any length of time, or the sum of all the elements of the current, was recorded, and that the force of the wind was taken into account along with the direction; thus affording more satisfactory data for meteorological speculations. This instrument was erected on the roof of the University about the middle of November 1837, and the register, as kept from that time till the 1st of April 1838, was presented in a tabular form.

The method of reducing these results was then explained. Groups of neighbouring winds were taken, and all the intercardinal were reduced to the cardinal points, by using certain multipliers, found by considering each intermediate point as the hypothenuse of a right-angled triangle; the east were subtracted from the west winds, and the north from the south, and the two resulting effective winds compounded, gave the mean magnitude and direction for the whole time during which the observations were made. These results were given in Tables, and also in the graphical form.

The observations with similar instruments at other stations have not been published, and therefore no comparison of results could be entered into.

Monday, 7th January 1839.

Dr ABERCROMBIE in the Chair.

The following Donations were presented:

Eulogy on Nathaniel Bowdich, LL.D., President of the American Academy of Arts and Sciences. By John Pickering.

A Eulogy on the Life and Character of Nathaniel Bowdich, LL. D., F. R. S. By Daniel Appleton White.

A Discourse on the Life and Character of the Hon. Nathaniel Bowdich, LL. D., F. R. S. By Alexander Young.

By the American Academy.

Journal of the Statistical Society of London for December 1838.—*By the Society.*

Memoirs of the Wernerian Natural History Society for the Years 1831–37. Vol. vii.—*By the Society.*

The Journal of the Royal Geographical Society of London. Vol. viii. Parts 2, 3.—*By the Society.*

A Sketch of the Geology of Fife and the Lothians, including detailed Descriptions of Arthur's Seat and Pentland Hills. By Charles Maclaren, Esq., F. R. S. E.—*By the Author.*

The American Journal of Science and the Arts.

Conducted by Benjamin Silliman jun., A. B.—*By the Editor.*

Memorie della Reale Accademia della Scienze di Torino. Tome xl.—*By the Academy.*

Transactions of the Institution of Civil Engineers. Vol. ii.—*By the Institution.*

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences (1838, 2^{me} Semestre). Nos. 23, 24, 25.—*By the Academy.*

Journal of the Asiatic Society of Bengal. April, May, June, 1838.—*By the Society.*

The following Communications were read:

1. Notice respecting an Intermitting Brine Spring discharging Carbonic Acid Gas, near Kissingen in Bavaria. By Professor Forbes.

The watering-place of Kissingen is situated in north latitude 49° 50′ east longitude, 9° 50′ from Greenwich, 60 English miles east of Frankfort. Long before it was frequented for medical purposes, its salt springs were turned to profitable account. Of these there are several, but the one recently enlarged by boring, known under the name of the *Runde Brunnen,* is much more remarkable than the others, on account of its Copiousness, its Temperature, its discharge of Carbonic Acid Gas in vast quantity, and its extraordinary phenomenon of Intermission.

The spring rises through the new red sandstone, of which the valleys in the neighbourhood of Kissingen are composed, on the left bank of the river Saal, whose course is marked for many miles by the occurrence of mineral springs, and by the discharge of carbonic acid gas. The author supposes its direction to be connected with a line of fissure, and the gas to have its origin in the neighbouring extinct volcanic focus of the Rhöngebirge.

The present spring was bored for in 1822, and the 4-inch shaft was carried to a depth of 323 Bavarian feet from the surface; but at the top it expands into a well eight feet in diameter. At a depth of 156 feet, the water ebbed for the first time, and it has done so since with more or less regularity; but what is particularly strange is, that this regularity appears to depend in a not very conceivable way upon the action of the pumps which are employed to raise the brine from the shaft for the purpose of evaporation. Whilst the pumping machinery works, the ebb and flow of the spring are very regular; when it stops, the regularity nearly ceases. When the spring is in full flow, its appearance is very striking. The great shaft of eight feet in diameter is filled with water, agitated in the most violent manner by the torrents of gas which it discharges. Whilst its turbulence is at a maximum, the gas abruptly ceases to flow, and in a few seconds the surface of the water in the shaft is perfectly tranquil. The water descends, and continues to do so, at first rapidly, then more slowly, until it has subsided nine or ten feet, which occurs in about fifteen minutes. This point has been but just reached, or for a very short time, when a sudden swelling up of the water first, and then of the gas, is observed in the bottom; the shaft fills very slowly,—the flow of water and of gas continue for a long time progressively to increase, not apparently attaining their maximum until the water is at its full height, which requires from thirty to forty minutes after the first return of the stream. It remains in a state of violent agitation for two hours, or somewhat more, when the preceding cycle of phenomena is repeated. This description applies to the ordinary state of the spring, when five or six pumps are in action; if these are fewer the periods are longer; if more, the reverse. This Mr Forbes clearly made out, from registers of observations frequently verified by himself. Of the natural state of the spring, when no pumps work, he had not the same means of satisfying himself. There can be no doubt, however, that, in that case, the periods are longer and more uncertain, those of flow amounting to three, four, or five hours, and of ebb to one, two, or three. Several of the neighbouring springs appear to partake of the intermittent character, especially as regards the carbonic acid gas which they discharge.

The temperature of the spring, many times observed during its various phases, was 65° Fahr. very nearly, and it seemed perfectly stationary. Now, it appears from direct observations, that the mean temperature of the air at Kissingen is about 51°, or 14° lower. The author made many observations upon the temperature of springs in the neighbourhood, both pure and mineral, which he finds to indicate a mean temperature rather lower than the above. Thus the great brine spring, in addition to its other remarkable characteristics, is distinctly *thermal*. Nor can this be ascribed to the depth of the bore through which it issues, for the spring which rose in the same spot before that bore was made had the same temperature half a century ago, and it did not increase during the operation of boring. A neighbouring spring, also intermittent and saline, called the Schönborn Quelle, rising through a bore 550 feet deep, has a temperature of only 52°.

Lastly, the author gives some account of the products of the spring. Thirty and a half cubic inches of almost pure carbonic acid gas are combined with one pound of water; but this gives no conception of the vast streams of that substance disengaged by the spring during its period of activity, and of which it is difficult to obtain the roughest measurement. It is collected and applied medicinally to different parts of the body, in baths suitably arranged. The water of the spring is discharged at the rate of from thirty-five to forty Bavarian cubic feet per minute during its full action. Its specific gravity is about 1.0157. The solid matter it contains amounts to 22.37 grains in 1000 of water, and consists, according to the analysis of Kastner, of 14 grains chloride of sodium, 3.2 muriate of magnesia, 0.5 muriate of lime, 3.3 sulphate of soda, 1.0 carbonates of magnesia and lime, together with several other substances in small quantity. It closely resembles the composition of sea-water. The brine is concentrated from 2½ to 17 per cent. by spontaneous evaporation in dropping through stacks of black thorn; and in this process at least 180 millions of pounds of water are annually carried off in the invisible form by the atmosphere. The quantity of pure salt obtained from this spring alone amounts to about 28,000 hundredweight (Bavarian Centner) yearly.

2. Notice on the Geology of Gottland, from the Observations of Mr Laing. By Dr Traill.

The fine Map of Sweden by Hissenger shews that the greatest part of that kingdom, to beyond the 61° N. Lat., may be characterized as a vast gneiss formation, skirted on the SW. and NE. by extensive detrital or alluvial formations.

The gneiss is interspersed with considerable tracts of granite, especially in the province of Ostergottland, and here and there exhibits small portions of hornblende-rock, porphyry, quartz-rock, mica-slate, and primary sandstone; but these rocks scarcely form any considerable tracts, and the scarcity of mica-slate is rather remarkable in a gneiss country.

The alluvial deposits consist of vast beds of clay, sand, and gravel, interspersed with greywacke-slate and transition limestone, with some mountain or encrinal limestone, lias beds, and oolite, and sparingly dotted with trap-rocks. The only considerable assemblages of these latter rocks are in two patches between the vast lakes the *Wenern* and the *Wettern*.

The constitution of the two most considerable Swedish islands, Oland and Gottland, are still more simple. They chiefly consist of encrinal limestone.

Gottland has a length of about seventy-six English miles, and its greatest breadth is thirty-four miles. Its general surface is flat, and in no point does it rise more than 200 feet above the sea. About one-tenth of its surface exhibits an oolitic limestone, bordered by a narrow stripe of sandstone on each side; which evidently belongs to the oolitic formation, from the nature of the organic remains found in them.

Petrifactions found in Gottland.

A. In the Mountain Limestone.

Crustacea
- Calymene, 4 species.
- Asaphus caudatus.
- Cytherina Balthica.

Cephalopoda
- Orthoceratites, 5 species.
- Ammonites Dalmanni.
- Nautilites complanatus.

Gasteropoda
- Turbinites, 2 or 3 species.
- Delphinula, 6 species.

Gasteropoda
- Euomphalus, 4 species.
- Turritella cingulata.

Acephala
- Modiola Gothlandica.
- Tellina Gothlandica.

Brachiopoda
- Septæna, 4 species.
- Orthis, 5 species.
- Eyrtia, 2 species.

- *Brachiopoda*
  - Delthyris, 7 species.
  - Atrypa, 7 species.
  - Terebratula, 8 species.
- *Crinodea*
  - Aprocrinites, 2 species.
  - Actiocrinites, 3 species.
  - Cyathocrinites, 3 species.
  - Other Encrinites, 5 or 6 species.
- *Sphæronites*
  - S. Ornatus.
- *Corallina*
  - Catenepora, 2 species.
  - Aulopora, 2 species.
  - Syringopora, 4 species.
  - Calomopora, 5 species.
  - Flustra lanceolata.
- *Corallina*
  - Sarcinula organum.
  - Astrea, 3 species.
  - Meandrina.
  - Fungites patellaris.
  - Cyclolites numismalis.
  - Turbinolia, 4 species.
  - Cyathophyllum, 6 species.
  - Lithodendron oculinum.
  - Caryophylla, 2 species.
  - Milleflora solida.
  - Nulliflora.
  - Retepora Clathrata.
- *Alcyonia*
  - Scyphia Empleura.
  - Siphonia præmorsa.
  - Phacites Gothlandicus.

B. In the Oolite and Sandstone.

Calymene Blumenbachi.
Cytherina.
Belemnites.
Turritellites.
Plagiostoma giganteum.
Avicula, 2 species.
Area.
Pectunculus.
Lephæna Englypha.
Orthis, 2 species.
Delthyris sulcata.
Atrypa reticularis.
Terebratula plicatella.
Aulopora serpens.
Calamopora Gothlandica.
Flustra lanceolata.
Phacites Gothlandicus.

Specimens of *mountain-meal* was brought by Mr Laing from the parish of Degersfors, on the northern branch of the river Umea in Umea-Lapmark. It was discovered in July 1832 by a farmer in cutting down a tree. It forms a bed under moss, and has been used by the natives, mixed with rye-flour, to form bread, and boiled to make gruel. Government prohibited it on the idea of its being unwholesome.

Dr Traill found that it does not effervesce with acids; that it loses by calcination 24 per cent., and becomes more white after first blackening. The odour seems partly animal. The microscope shews it to consist chiefly of bodies that have the form of elongated and flattened elliptic bodies, probably the remains of infusoria. Dr Traill is analyzing it, and considers it, from his preliminary experiments, to consist chiefly of silica.

In the same district, in bad years, the farmers make a bread of half rye-flour and half bark. The inner bark of the pine is washed, dried, and pounded, for this purpose. Specimens of this bread were exhibited.

3. Notice regarding some points in Hydrodynamics that have been misunderstood. By Mr Scott Russell.

This notice is occasioned by a passage in the fifth volume of the Transactions of the British Association, page 251, in which Professor Challis claims for himself the merit of having been the first who deduced from mechanical principles the anomalous emergence of a floating body from a fluid at high velocities, and where he adduces Mr Russell's experiments in support of the method of reasoning he has there adopted. Previous to the publication of his paper, Mr Russell had given the theoretical explanation of the phenomenon, and had also adduced experiments in support of that explanation at the meeting of the British Association in Edinburgh. The object of this notice is not, however, to argue the claim to priority of discovery, which the author of this notice considers of little importance, provided the truths accordant with the phenomenon have been rightly determined; but his present aim is to remove certain misconceptions into which Professor Challis has fallen in regard to the nature of the phenomenon he has explained,—misconceptions of a grave nature, not merely as regards theory, but which are likely to produce a most injurious effect upon the practical application of these principles; for it appears that practical men have also been led astray by the authority of Professor Challis's name, and the imposing apparatus of calculus, which they were not able either to understand or expose: and, accordingly, we find the author of the last paper in the first volume of the Transactions of the Institute of Civil Engineers misled by Professor Challis, and a Mr Woolhouse, who has edited a second edition of Tredgold on the Steam-Engine, adopting similar views.

Now, as Professor Challis had adduced Mr Russell's researches in support of his views, he is thus brought in for a share of responsibility for the defect of those views, and has therefore felt it incumbent on him to place the question in its true light.

The following is the passage in Mr Challis's report:

"The circumstance of floating bodies rising vertically when drawn with considerable velocities along the surface of the water, having attracted attention a few years ago, induced me to try to explain the fact on mechanical principles; and, accordingly, in a paper published in the Cambridge Philosophical Transactions, I have entered on a mathematical investigation, which accounts for such a fact, and shews that, when the velocity of draught is uniform, the rise is proportional to the square of the velocity, in accordance with an experimental result obtained by Mr Russell. This inquiry is not pursued farther in that paper (though I believe it may be done according to the method here employed), the immediate object in view being to gain confidence for the particular process of reasoning adopted, by explaining to a considerable extent a fact which had not before been shewn to depend on received mechanical principles."

On examining Professor Challis's reasoning in the paper referred to, and divesting it of its technical form, it appears to be this;—that if you suppose the bow of a vessel to be of a spherical form, or what nautical men term "a spoon bow," and conceive it drawn through the water rapidly, the force of impact of the bow and the water may be resolved into two parts, one of which tends to throw the bow upwards, and being a given part of the whole resistance, tends to throw it up with a force proportional to the square of the velocity.

In other words, Mr Challis has expressed in mathematical terms what was at that time the prevalent and vulgar error on this subject. It was early supposed by those who witnessed the phenomena referred to, that the bow of the boat rose in the manner Professor Challis conceives, and, as the immediate inference from this, it was considered that the boat whose bow was most nearly of the spoon form would be that which, according to these views, would rise most and have least resistance; but, on the contrary, on building boats of this form which should have the greatest emergence and least resistance, according to the view adopted by Professor Challis, it turned out that they were the very opposite, and that, on altering them to the form of the most acute wedge in which, by Mr Challis's method, they could have no emergence, and no diminution of resistance, they became the very reverse of what had been supposed. Thus it occurred that a very simple experiment put them right, and overturned the views of Professor Challis.

The effect which Mr Challis conceives he has accounted for is one of a totally different nature, and indeed the opposite of what he has imagined. It is well known to every one at all acquainted with the motion of boats, or the theory of their construction, that a full or spherical bow is violently raised up when propelled at high velocities; but it happens unfortunately that the stern is violently depressed, while the resistance is greatly increased. Now Professor Challis's view would require the vessel to be wholly raised above the statical immersion, and the resistance diminished,—the reverse of the fact. It is further proved by experiment, that when the emergence which Professor Challis has examined takes place to the greatest extent, the resistance is at its maximum, whereas, according to him, it should be a minimum.

Whatever use, therefore, practical men may be induced to make of the reasoning of Mr Challis, it may be expected to lead them to results the reverse of what they intended.

The kind of emergence of a floating body from the surface of a fluid, which Professor Challis states that he was the first to explain on mechanical principles, is therefore of a different nature from that which he intended to explain, and is due only to the peculiarity of the form of the body. It is not the kind of emergence to which any of the phenomena he wished to explain are due.

The essential principle on which Mr Russell has explained the tendency to emergence of all bodies at high velocities, independent of their figure, is this: The gravity of a body is the cause and measure of its displacement. This gravitation, during a given interval of time, is a given constant quantity. The quantity of fluid displaced by a floating body in motion, in virtue of the gravitating force, is variable, increasing with the velocity. The gravitating force of the body during a second is a given quantity, acting downwards. The pressure of all the fluid displaced in a second is another force opposed to the former, and acting upwards on the bottom of the vessel. From these two forces an equation is formed, which gives the amount of emergence depending only on velocity, and an expression results, into which the former does not enter: this result was afterwards confirmed by experiment.

It is only necessary, in conclusion, to state, that these discussions have nothing to do with the phenomena of the wave, to which alone the chief anomalies of resistance are due.